

CHAPTER 3

DESIGN CRITERIA

3-1. Introduction. This chapter prescribes the criteria for the seismic design of buildings and other structures based on an equivalent static force procedure.

3-2. General. The seismic design of buildings and other structures will be in accordance with the criteria and design standards herein. The structural system or type of construction will be based on a rational analysis in accordance with established principles of mechanics. Structures will be designed for dead, live, snow, wind, and seismic forces. The dead, live, snow, and wind loads will be as given in TM 5-809-1/AFM 88-3, Chap 1. Every building or structure and every portion thereof will be designed and constructed to resist stresses produced by lateral seismic forces in combination with dead and live loads as provided in this chapter. Materials and details will conform to the seismic provisions, applicable guide specifications, and criteria herein. The provisions of this chapter apply to the structure as a unit and also to all of its parts. In Zone 1, if the seismic base shear is less than one-third of the total lateral wind forces on the building, a seismic design is not required. In Zone 0 there are no seismic requirements.

3-3. Seismic design provisions. The seismic provisions of this manual are in accordance with SEAOC, except as modified herein. They are obtained from the following sources—

a. Structural Engineers Association of California (SEAOC). The 1990 edition of the SEAOC recommendations, which includes recommendations, appendixes, and commentary, is the basic reference document. The SEAOC recommendations are discussed at appropriate places in this manual. References in this manual to SEAOC provisions have the following format: “SEAOC 1D8a” refers to Section 1D8a of the SEAOC provisions. Detailed explanations of the SEAOC provisions will be found in the SEAOC commentary.

b. American Concrete Institute (ACI). ACI 318 is the basic reference for concrete construction in this manual. Chapter 21 of ACI 318-89 is the basic reference for seismic provisions. References in this manual to ACI provisions have the following format: “ACI 21.3.1” refers to Section 3.1 of Chapter 21 of ACI 318-89. The SEAOC recommendations are based on ACI 318-83, including ACI Appendix A as amended by SEAOC. These amendments, given in SEAOC Chapter 3, have been

superseded. Refer to appendix C in this manual for equivalent amendments to Chapter 21 of ACI 318-89. In ACI 21.2.1, regions of moderate seismic risk should be understood to be Seismic Zone 2; regions of high seismic risk, Zones 3 and 4.

c. American Institute of Steel Construction (AISC). The *Manual of Steel Construction* is the basic reference for steel construction in this manual. Because the SEAOC recommendations were completed before the 9th edition was published, the provisions for seismic design of steel frames given in SEAOC Chapter 4 reference the 8th edition of the AISC manual. The SEAOC references to AISC have to do with exceptions to AISC regarding such things as allowable stresses and width-thickness ratios. References in this manual to the AISC manual have the following format: “AISC 1.4.1” refers to Section 1.4.1 of the specifications in the AISC manual. To use the 9th edition of the AISC ASD manual, refer to the conversion table on AISC in the specifications.

d. International Conference of Building Officials (ICBO). The SEAOC provisions refer to the *Uniform Building Code (UBC)*, published by ICBO.

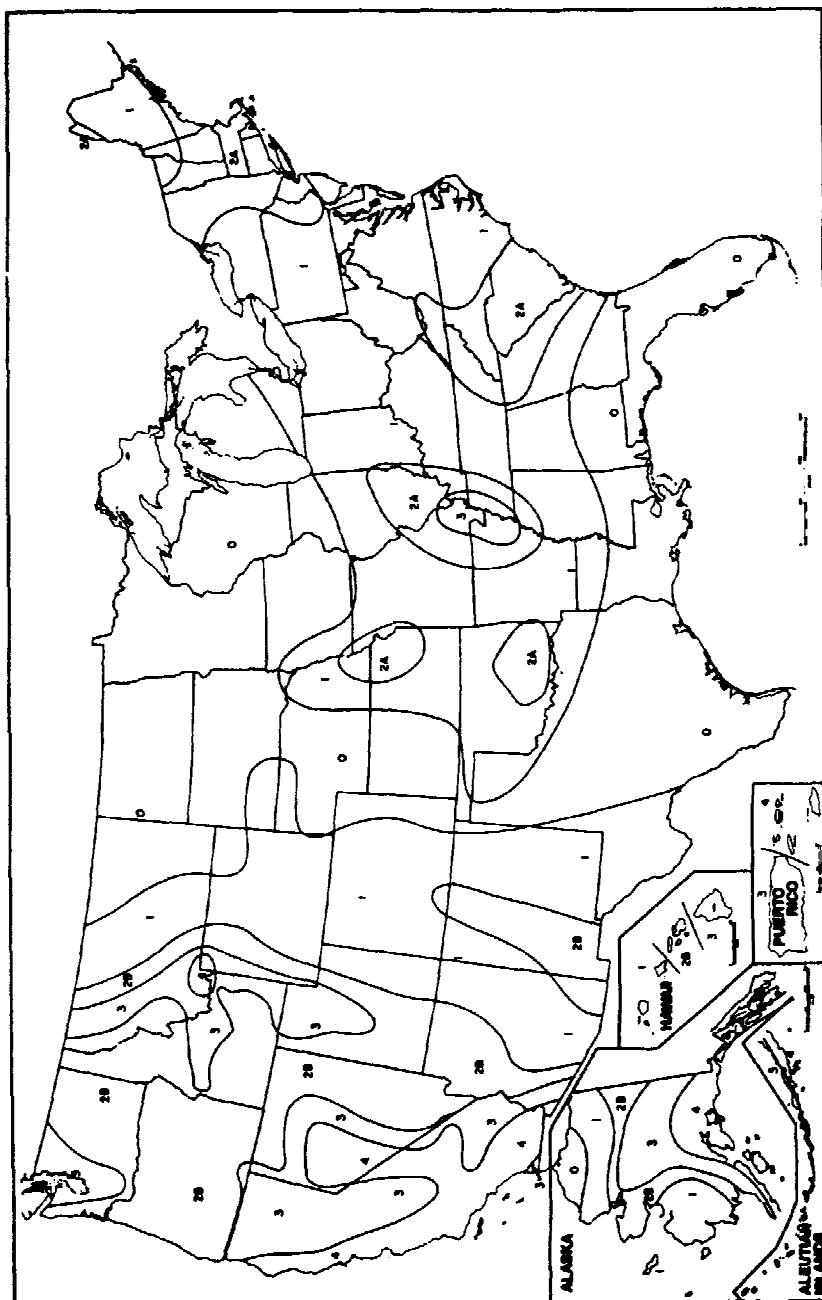
3-4. Seismic zone map. The seismic zones used to determine the factor Z are shown in figure 3-1. Seismic zones for specific areas are tabulated in tables 3-1 and 3-2 for localities within and outside the United States, respectively. Table 3-1 takes precedence over the map. For sites not covered by the tables, note that the map boundary lines are approximate, and in the event of any conflict or uncertainty regarding the applicable zone of any particular site, the higher zone will be used.

3-5. Seismic zone factor, Z . The factor Z is determined by the seismic zone:

- Zone 4, $Z = 0.40$
- Zone 3, $Z = 0.30$
- Zone 2B, $Z = 0.20$
- Zone 2A, $Z = 0.15$
- Zone 1, $Z = 0.075$

3-6. Types of occupancy. The following descriptions of military service occupancy categories supplement or modify SEAOC 1D4 unless other directions are given by the user agency. Refer to SEAOC Table 1-C for SEAOC occupancy categories.

a. Category I—Essential Facilities. These are critical facilities that are necessary for postdisaster recovery and must be kept operating continuously



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Figure 3-1. Seismic zone map of the United States.

ALABAMA		COLORADO		ILLINOIS (cont'd)	
Aniston	2A	USAF Academy	1	Savanna AD	1
Maxwell AFB	0	Fort Carson	1	Scott AFB	2A
Birmingham	2A	Denver	1		
Huntsville	1	Fitzsimmons AMC	1		
Mobile	0	Peterson Field	1	INDIANA	
Montgomery	0	Pueblo	1	Fort Ben Harrison	2A
Fort Rucker	0			Fort Wayne	2A
				Grisson AFB	1
				Indiana AAP	2A
ALASKA		CONNECTICUT			
Adak Island	4	Hartford	2A	IOWA	
Anchorage	4	New Haven	2A	Burlington	0
Aleutian Islands	4	New London	2A	Cedar Rapids	0
Barrow	1			Des Moines	0
Bethel	2B	DELAWARE		Sioux City	1
Elmendorf AFB	3	Dover AFB	1		
Elmendorf AFB	4	Wilmington	2A		
Fairbanks	3			KANSAS	
Fort Greely	3	FLORIDA		Kansas AAP	1
Juneau	3	Eglin AFB	0	Fort Leavenworth	2A
Kodiak Island	4	Homestead AFB	0	McConnell AFB	1
Nome	1	Jacksonville	1	Fort Riley	2A
		Key West	0	Sunflower AAP	2A
ARIZONA		MacDill AFB	0		
Fort Huachuca	2B	Miami	0	KENTUCKY	
Luke AFB	1	Orlando	0	Fort Campbell	2A
Navajo AD	1	Patrick AFB	0	Lexington	1
Phoenix	1	Pensacola	0	Louisville	2A
Tucson	1	Tampa	0	Fort Knox	2A
Williams AFB	1	Tyndall AFB	0		
Yuma	4			LOUISIANA	
Yuma Proving Grounds	3	GEORGIA		Fort Polk	0
		Albany	1	Lake Charles	1
ARKANSAS		Atlanta	2A	Louisiana AAP	1
Baker AFB	3	Fort Benning	1	New Orleans	0
Fort Chaffee	1	Fort Gordon	2A	Shreveport	1
Little Rock AFB	1	Hunter AFB	2A		
Pine Bluff	1	Macon	1	MAINE	
		Robins AFB	1	Bangor	1
		Savannah	2A	Brunswick	2A
		Fort Stewart	1	Cuttler	2A
				Loring AFB	1
				Winter Harbor	1
CALIFORNIA		HAWAII			
Castle AFB	3	Barbers Point, Oahu	2B	MARYLAND	
China Lake	4	Hickam AFB	2B	Aberdeen Proving Ground	1
Edwards AFB	4	Hilo, Hawaii	4	Andrews AFB	1
Hamilton AFB	4	Honolulu, Oahu	2B	Annapolis	1
Hunter-Liggett MR	4	Kaneohe Bay, Oahu	2B	Baltimore	1
Long Beach	4	Lihue, Kauai	1	Fort Detrick	1
Los Angeles	4	Schofield Barracks	2B	Fort Meade	1
March AFB	4	Wheeler AFB	2B	Fort Ritchie	1
Mare Island	4	Wailuku, Maui	3		
Norton AFB	4			MASSACHUSETTS	
Oakland	4	IDAHO		Boston	2A
Fort Ord	4	Idaho Falls	2B	Fort Devens	2A
Camp Pendleton	4	Mountain Home AFB	2B	L.G. Hanscom Field	2A
Port Hueneme	4			Otis AFB	2A
Sacramento	3	ILLINOIS		Westover AFB	2A
San Diego	4	Chanute AFB	1		
San Francisco	4	Chicago	1	MICHIGAN	
Sharpe AD	3	Great Lakes TC	1	Detroit	1
Sierra AD	3	Joliet AAP	1	Kincheloe AFB	1
Travis AFB	4	O'Hare IAP	1		
Vandenberg AFB	4	Rock Island Arsenal	1		

Table 3-1. Seismic zone tabulation—United States.

MICHIGAN (cont'd)			NORTH CAROLINA			SOUTH DAKOTA		
K.I. Sawyer AFB	0		Fort Bragg	1		Ellsworth AFB	1	
Selfridge AFB	1		Charlotte	2A		Pierre	0	
Wurtsmith AFB	0		Camp Lejeune	1		Sioux Falls	0	
			Greensboro	2A				
MINNESOTA			Pope AFB	1		TENNESSEE		
Duluth	0		Seymour Johnson	1		Chattanooga	2A	
Minneapolis	0		Sunny Point Ocean			Holston AAP	2A	
Osceola AFB	0		Terminal	1		Memphis	3	
						Milan AAP	3	
MISSISSIPPI						Millington	3	
Biloxi	0		NORTH DAKOTA			Nashville	1	
Columbus AFB	1		Bismarck	0				
Jackson	1		Fargo	0				
Keeler AFB	0		Grand Forks AFB	0				
Meridan	1		Minot AFB	0				
MISSOURI			OHIO					
Kansas City	2A		Cincinnati	1		TEXAS		
Lake City AAP	2A		Cleveland	1		Austin/Bergstrom AFB	0	
Fort Leonard Wood	1		Columbus	1		Brooks AFB	0	
St. Louis	2A		Ravenna AAP	1		Carswell AFB	0	
Richards Gebaur AFB	2A		Wright-Patterson AFB	1		Corpus Christi	0	
Whiteman AFB	1					Dallas	0	
						Dyess AFB	0	
MONTANA						Ellington AFB	0	
Helena	3		OKLAHOMA			El Paso	1	
Malmstrom AFB	2B		Enid/Vance AFB	1		Fort Bliss	1	
Missoula	2B		Fort Sill	1		Fort Sam Houston	0	
			Tinker AFB	2A		Galveston	0	
			Tulsa	1		Goodfellow AFB	0	
			McAlester AAP	2A		Fort Hood	0	
			Altus AFB	1		Fort Worth	0	
						Houston	0	
NEBRASKA						Kelly AFB	0	
Cornhusker AAP	1					Lackland AFB	0	
Lincoln	1		OREGON			Laughlin AFB	0	
Offutt AFB	1		Coos Bay	2B		Lone Star AAP	1	
			Eugene	2B		Longhorn AAP	1	
			Portland	2B		Randolph AFB	0	
			Umatilla AD	2B		Red River AD	1	
						Reese AFB	0	
NEVADA						San Antonio	0	
Carson City	3					Sheppard AFB	1	
Fallon	4		PENNSYLVANIA			Wichita Falls	0	
Hawthorne	4		Carlisle Barracks	1				
Las Vegas	2B		Harrisburg	1				
			Letterkenny AD	1				
			Philadelphia	2A				
NEW HAMPSHIRE			Pittsburgh	1				
Hanover	2A		Scranton	2A				
Pease AFB	2A							
Portsmouth	2A							
NEW JERSEY								
Atlantic City	1							
Bayonne	2A							
Picatinny Arsenal	2A							
McGuire AFB	1							
Fort Monmouth	2A							
NEW YORK								
Albany	2A							
Buffalo	2A							
Fort Drum	2A							
Griffiss AFB	2A							
New York	2A							
Niagara Falls IAP	2A							
Plattsburg AFB	2A							
Syracuse	1							
West Point Military								
Reservation	2A							
Watervliet	2A							

Table 3-1. Continued.

WASHINGTON	
Bremerton	3
Fairchild AFB	2B
Fort Lewis	3
McChord AFB	3
Seattle	3
Walla Walla	2B
Yakima	2B
WASHINGTON, DC	
Bolling AFB	1
Fort McNair	1
Walter Reed AMC	1
WEST VIRGINIA	
All	1
WISCONSIN	
All	0
WYOMING	
Cheyenne	1
Yellowstone	3

Table 3-1. Continued

during and after an earthquake. This category includes facilities where damage from an earthquake may cause significant loss of strategic and general communications and critical mission response capability. In addition to the items in SEAOC Table 1-C, the following are categorized as essential facilities:

(1) Facilities involved in handling or processing sensitive munitions, nuclear weaponry or materials, gas and petroleum fuels, and chemical or biological contaminants.

(2) Facilities involved in operational missile control, launch, tracking, or other critical defense capabilities.

(3) Mission-essential and primary communication or data-handling facilities.

b. Category II—Hazardous Facilities. These are defined in SEAOC Table 1-C.

c. Category III—Special Occupancy Structures. These are structures where primary occupancy is for assembly of a large number of people, where the primary use is for people who are confined (e.g., prisons), or where services are provided to a large area or large number of other buildings. Buildings in this category may suffer damage in a large earthquake but are recognized as warranting a higher level of safety than the average building. An example of a special occupancy structure is one having high-value equipment when justification is provided by the using agency.

d. Category I V—Standard Occupancy Structures. This category includes all facilities not included in the categories above.

e. Multiple occupancies. Buildings with multiple occupancies will be categorized according to the most important occupancy unless the portion of the

building that houses the most important occupancy can be shown to satisfy the requirements for that occupancy.

3-7. Importance factors. The importance factor is a multiplier that increases the design lateral force levels for certain occupancies. Values of I-factors for all occupancy categories are given in SEAOC Table 1—D. Use of these I-factors requires that specific quality control requirements be met. These requirements are discussed in SEAOC.

3-8. Approved systems. Any building designed within the scope of this manual must qualify under one or more of the classifications under general categories A, B, C, and D in SEAOC Table 1-G. If there is doubt as to which of two classifications governs, the one with the smaller value of R_w should be used. If the building does not appear to be covered by any of the classifications, the structural system must be modified to conform to one of the classifications, or justification must be made for the argument that the structural system will satisfy the intent of the seismic design provisions as prescribed in SEAOC 1D9b.

3-9. Dynamic analysis. TM 5-809-10-1/NAVFAC P-355.1/AFM 88-3, Chap 13, Sec A, will be used instead of SEAOC 1F when the dynamic analysis procedure is used.

3-10. Quality control.

a. General. The SEAOC provisions require that a certain level of quality control be provided. Observation of actual structural performance in earthquakes has indicated that the details of design

and construction often dominate the seismic performance. The SEAOC provisions are based on the premise that special design, construction review, inspection, and observation can improve the performance of the structure more effectively than reliance on increased design force levels. In Zones 2, 3, and 4, for Occupancy Categories I, II, and III,

SEAOC 1K requires that special quality control requirements be exercised during both the design phase and the construction phase of a project. When standard Department of Defense (DOD) quality control procedures do not meet the SEAOC 1K requirements, supplemental procedures should be initiated to meet these requirements.

AFRICA:

Algeria:	
Alger	3
Oran	3
Angola:	
Luanda	0
Benin:	
Cotonou	0
Botswana:	
Gaborone	0
Burundi:	
Bujumbura	3
Cameroon:	
Douala	0
Yaounde	0
Cape Verde:	
Prata	0
Central African Republic:	
Bangui	0
Chad:	
Ndjamena	0
Congo:	
Brazzaville	0
Djibouti:	
Djibouti	3
Egypt:	
Alexandria	2A
Cairo	2A
Port Said	2A
Equatorial Guinea:	
Malabo	0
Ethiopia:	
Addis Ababa	3
Asmara	3
Gabon:	
Libreville	0
Gambia:	
Banjul	0
Ghana:	
Accra	3
Guinea:	
Bissau	1
Conakry	0
Ivory Coast:	
Abidjan	0
Kenya:	
Nairobi	2A
Lesotho:	
Maseru	2A
Liberia:	
Monrovia	1
Libya:	
Tripoli	2A
Wheelus AFB	2A
Malagasy Republic:	
Tananarive	0
Malawi:	
Blantyre	3
Lilongwe	3
Zomba	3

Mali:	
Bamako	0
Mauritania:	
Nouakchott	0
Mauritius:	
Port Louis	0
Morocco:	
Casablanca	2A
Port Lyautcy	1
Rabat	2A
Tangier	3
Mozambique:	
Maputo	2A
Niger:	
Niamey	0
Nigeria:	
Ibadan	0
Kaduna	0
Lagos	0
Republic of Rwanda:	
Kigali	3
Senegal:	
Dakar	0
Seychelles:	
Victoria	0
Sierra Leone:	
Freetown	0
Somalia:	
Mogadishu	0
South Africa:	
Cape Town	3
Durban	2A
Johannesburg	2A
Natal	1
Pretoria	2A
Swaziland:	
Mbabane	2A
Tanzania:	
Dar es Salaam	2A
Zanzibar	2A
Togo:	
Lome	1
Tunisia:	
Tunis	3
Uganda:	
Kampala	2A
Upper Volta:	
Ougadougou	0
Zaire:	
Bukavu	3
Kinshasa	0
Lubumbashi	2A
Zambia:	
Lusaka	2A
Zimbabwe:	
Harare	
(Salisbury)	3

ASIA:

Afghanistan:	
Kabul	4
Bahrain:	
Manama	0

Bangladesh:	
Dacca	3
Brunei:	
Bandar Seri Begawan	1
Burma:	
Mandalay	3
Rangoon	3
China:	
Canton	2A
Chengdu	3
Nanking	2A
Peking	4
Shanghai	2A
Shengyang	4
Tihwa	4
Tsingtao	3
Wuhan	2A
Cyprus:	
Nicosia	3
Hong Kong:	
Hong Kong	2A
India:	
Bombay	3
Calcutta	2A
Madras	1
New Delhi	3
Indonesia:	
Bandung	4
Jakarta	4
Medan	3
Surabaya	4
Iran:	
Isfahan	3
Shiraz	3
Tabriz	4
Tehran	4
Iraq:	
Baghdad	3
Basra	1
Israel:	
Haifa	3
Jerusalem	3
Tel Aviv	3
Japan:	
Fukuoka	3
Itazuke AFB	3
Misawa AFB	3
Naha, Okinawa	4
Osaka/Kobe	4
Sapporo	3
Tokyo	4
Wakkanai	3
Yokohama	4
Yokota	4
Jordan:	
Amman	3
Korea:	
Kwangju	1
Kimhae	1
Pusan	1
Seoul	0
Kuwait:	
Kuwait	1

Table 3-2. Seismic zone tabulation—outside United States.

Laos:	
Vientiane	1
Lebanon:	
Beirut	3
Malaysia:	
Kuala Lumpur	1
Nepal:	
Kathmandu	4
Oman:	
Muscat	2A
Pakistan:	
Islamabad	4
Karachi	4
Lahore	2A
Peshawar	4
Qatar:	
Doha	0
Saudi Arabia:	
Al Batin	1
Dhahran	1
Jiddah	2A
Khamis Mushayf	1
Riyadh	0
Singapore:	
All	1
South Yemen:	
Aden City	3
Sri Lanka:	
Colombo	0
Syria:	
Aleppo	3
Damascus	3
Taiwan:	
All	4
Thailand:	
Bangkok	1
Chiang Mai	2A
Songkhla	0
Udon	1
Turkey:	
Adana	2A
Ankara	2A
Istanbul	4
Izmir	4
Karamursel	3
United Arab Emirates:	
Abu Dhabi	0
Dubai	0
Viet Nam:	
Ho Chi Minh City(Saigon)	0
Yemen Arab Republic:	
Sanaa	3

ATLANTIC OCEAN AREA:

Azores:	
All	2A
Bermuda:	
All	1

CARIBBEAN SEA:

Bahama Islands:	
All	1

Cuba:	
All	2A
Dominican Republic:	
Santo Domingo	3
French West Indies:	
Martinique	3
Grenada:	
Saint Georges	3
Haiti:	
Port au Prince	3
Jamaica:	
Kingston	3
Leeward Islands:	
All	3
Puerto Rico:	
All	2B
Trinidad & Tobago:	
All	3

CENTRAL AMERICA:

Belize:	
Belmopan	2A
Canal Zone:	
All	2A
Costa Rica:	
San Jose	3
El Salvador:	
San Salvador	4
Guatemala:	
Guatemala	4
Honduras:	
Tegucigalpa	3
Nicaragua:	
Managua	4
Panama:	
Colon	3
Galeta	2B
Panama	3
Mexico:	
Ciudad Juarez	2A
Guadalajara	3
Hermosillo	3
Matamoros	0
Mazatlan	2A
Merida	0
Mexico City	3
Monterrey	0
Nuevo Laredo	0
Tijuana	3

EUROPE:

Albania:	
Tirana	3
Austria:	
Salzburg	2A
Vienna	2A
Belgium:	
Antwerp	1
Brussels	2A

Bulgaria:	
Sofia	3
Czechoslovakia:	
Bratislava	2A
Prague	1
Denmark:	
Copenhagen	1
Finland:	
Helsinki	1
France:	
Bordeaux	2A
Lyon	1
Marseille	3
Nice	3
Paris	0
Strasbourg	2A
Germany, Federal Republic:	
Berlin	0
Bonn	2A
Bremen	0
Dusseldorf	1
Frankfurt	2A
Hamburg	0
Munich	1
Stuttgart	2A
Vaihingen	2A
Greece:	
Athens	3
Kavalla	4
Makri	4
Rhodes	3
Sauda Bay	4
Thessaloniki	4
Hungary:	
Budapest	2A
Iceland:	
Keflavick	3
Reykjavik	4
Ireland:	
Dublin	0
Italy:	
Aviano AFB	3
Brindisi	0
Florence	3
Genoa	3
Milan	2A
Naples	3
Palermo	3
Rome	2A
Sicily	3
Trieste	3
Turin	2A
Luxembourg:	
Luxembourg	1
Malta:	
Valletta	2A
Netherlands:	
All	0
Norway:	
Oslo	2A
Poland:	
Krakow	2A
Poznan	1
Warszawa	1

Table 3-2. Continued.

Portugal:	
Liabon	4
Opporto	3
Romania:	
Bucharest	3
Spain:	
Barcelona	2A
Bilbao	2A
Madrid	0
Rota	2A
Seville	2A
Sweden:	
Goteborg	2A
Stockholm	1
Switzerland:	
Bern	2A
Geneva	1
Zurich	2A
United Kingdom:	
Belfast	0
Edinburgh	1
Edzell	1
Glasgow/Renfrew	1
Hamilton	1
Liverpool	1
London	2A
Londonderry	1
Thurso	1
U.S.S.R.:	
Kiev	0
Leningrad	0
Moscow	0
Yugoslavia:	
Belgrade	2A
Zagreb	3

NORTH AMERICA:

Greenland:	
All	1
Canada:	
Argentia NAS	2A
Calgary, Alb	1
Churchill, Man	0
Cold Lake, Alb	1
Edmonton, Alb	1
E. Harmon, AFB	2A
Fort Williams, Ont	0
Frobisher N.W.Ter	0
Goose Airport	1
Halifax	1
Montreal, Quebec	3
Ottawa, Ont	2A
St. John's Nfld	3
Toronto, Ont.	1
Vancouver	3
Winnipeg, Man.	1

SOUTH AMERICA:

Argentina:	
Buenos Aires	0

Brazil:	
Belem	0
Belo Horizonte	0
Brasilia	0
Manaus	0
Porto Alegre	0
Recife	0
Rio de Janeiro	0
Salvador	0
Sao Paulo	1
Bolivia:	
La Paz	3
Santa Cruz	1
Chile:	
Santiago	4
Valparaiso	4
Colombia:	
Bogata	3
Ecuador:	
Quito	4
Guayaquil	3
Paraguay:	
Asuncion	0
Peru:	
Lima	4
Piura	4
Uruguay:	
Montevideo	0
Venezuela:	
Maracaibo	2A
Caracas	4

PACIFIC OCEAN AREA:

Australia:	
Brisbane	1
Canberra	1
Melbourne	1
Perth	1
Sydney	1
Caroline Islands:	
Koror, Paulau Is.	2A
Ponape	0
Fiji:	
Suva	3
Johnson Island:	
All	1
Mariana Islands:	
Guam	3
Saipan	3
Tinian	3
Marshall Islands:	
All	1
New Zealand:	
Auckland	3
Wellington	4
Papau New Guinea:	
Port Moresby	3
Phillipine Islands:	
Cebu	4
Manila	4
Baguio	3

Table 3-2. Continued.